Smart Collaboration

Leverage a rich knowledge base to gain competitive advantage in the additive manufacturing industry

Adventures in 3D Printing, Roadmapping, and Public – Private Partnerships

Rob Gorham
America Makes
Director of Operations

National Center for Defense and Manufacturing and Machining (NCDMM)

Delivering Manufacturing Innovation

- Established 2003

- Non-profit

- Manufacturing Solution Provider

- Independent, Unbiased

- Project-Based (~100 active projects)

- Improve Cost, Quality, Performance

- Rapid Deployment to Industry and the Warfighter

- America Makes Administrator

Collaborate…

…with government, industry, and academia to promote best practices, and deliver them to key stakeholders…we "connect the dots"

Who We Are

Public / Private Partnership

America Makes has substantial federal, private industry, and academic investment.

Multi-Agency Collaboration

Partnership between industry, government and universities, led by the Defense-wide Manufacturing S&T team.

Membership

Innovation facility in Youngstown, Ohio with 175 members. We continue to grow.

Operations

We are operated by the National Center for Defense Manufacturing & Machining (NCDMM)

Collaborate, Cooperate, Innovate
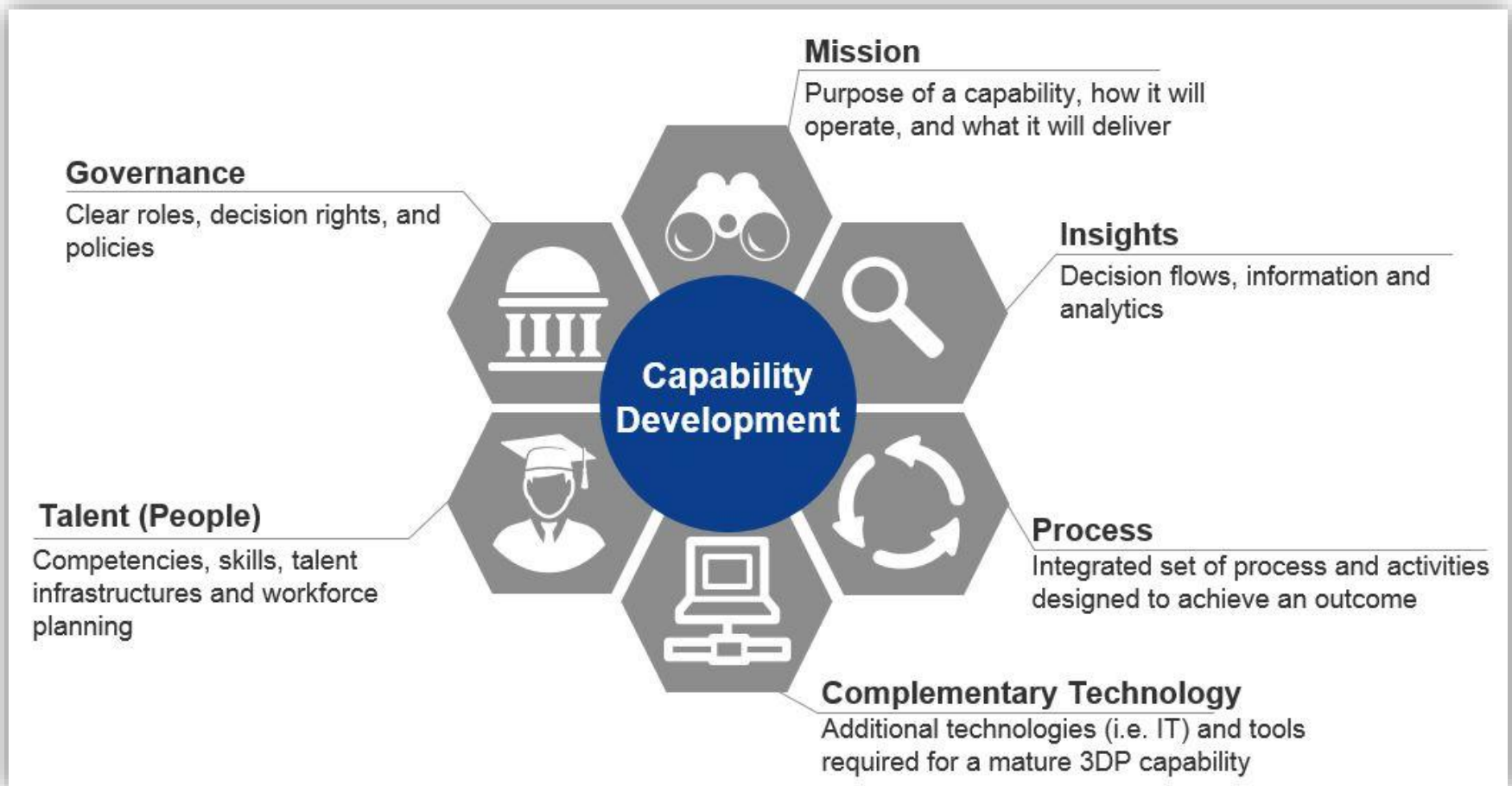
Technology Development

Technology Transition

Workforce and Educational Outreach

Focus: Robust, Sustainable Value Chain

Mission
Purpose of a capability, how it will operate, and what it will deliver

Governance
Clear roles, decision rights, and policies

Insights
Decision flows, information and analytics

Capability Development

Talent (People)
Competencies, skills, talent infrastructures and workforce planning

Process
Integrated set of process and activities designed to achieve an outcome

Complementary Technology
Additional technologies (i.e. IT) and tools required for a mature 3DP capability

Widespread adoption of AM depends on organizations developing AM *capabilities*, not just purchasing machines

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Summary of Capability Gaps / Issues

Need/Issue	Impact if not Addressed
Dimensional accuracy & surface finish	Additional processing cost, unusable parts
Uniform mechanical properties – different in build direction	Increased design complexity & added weight, suboptimal designs
Improved process control & repeatability	Acceptable part quality, process yield & cost
NDE methods for complex defects and part geometry-understanding of potential defects – effects of defects	Undetected defects leading to component failure.
AM Standards (Materials, process, machine, quality)	Slow implementation of AM in industrial base
Qualification and Certification protocols	Slow adoption, conflicting approaches, waste in research and sustainment dollars
Design tools for AM components	Suboptimal design, increased time to market, material waste, poor performance

America Makes Roadmapping

- America Makes has released v2.0 of the Technology Roadmap using a **systems engineering-based methodology**

- America Makes has partnered with Deloitte on a shared vision for growing from technology development to **capability development**

- Execute a continuous Systems Engineering-based approach to roadmap development, anchored by in-person workshops featuring a suite of enhanced **facilitation techniques**

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Deloitte.

DESIGN MATERIAL PROCESS VALUE CHAIN AM GENOME

Swimlane	Critical Technology Element	Impact Focus
Design	Bio-Inspired Design & Manufacturing	Complexity Exploitation, 3D Graded Materials, Multi-Material Integration, Model-Based Development, Product Customization
Design	Cost & Energy Driver Driver Analysiss	Complexity Exploitation, 3D Graded Materials, Multi-Material Integration, Model-Based Development, Product Customization
Design	Design Aides/Apps	Complexity Exploitation, 3D Graded Materials, Multi-Material Integration, Model-Based Development, Product Customization
Material	Additive Mfg Tech Data Packages	Standard Feedstock Materials, Benchmark Property Data, Microstructure Relationships, Process Window Definition, Processing Guidelines & Specifications
Material	Next-Gen Materials	Standard Feedstock Materials, Benchmark Property Data, Microstructure Relationships, Process Window Definition, Processing Guidelines & Specifications
Material	Powder/Material Characterization	Standard Feedstock Materials, Benchmark Property Data, Microstructure Relationships, Process Window Definition, Processing Guidelines & Specifications
Process	Multi-Material Delivery & Deposition	Faster Build Speeds, Improved Surface Quality, Larger Part Envelopes, Improved Detail Capability
Process	Next-Gen Machines	Faster Build Speeds, Improved Surface Quality, Larger Part Envelopes, Improved Detail Capability
Process	Process Temperature Gradient Control	Faster Build Speeds, Improved Surface Quality, Larger Part Envelopes, Improved Detail Capability
Value Chain	Digital Thread Integration	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
Value Chain	Advanced Sensing & Detection Methods	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
Value Chain	Intelligent Machine Control Methods	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
Value Chain	Rapid Inspection (Post Build)	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
Value Chain	Repair Technologies	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
Value Chain	Standards/Schemas/Protocols	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
AM Genome	Benchmark Validation Use Cases	Concurrent Methods, Computational Tools, Experimental Tools, Modular Open Simulations, Open Multi-Scale Data
AM Genome	Physics-Based Modeling & Simulation	Concurrent Methods, Computational Tools, Experimental Tools, Modular Open Simulations, Open Multi-Scale Data
AM Genome	Model-Assisted Property Prediction	Concurrent Methods, Computational Tools, Experimental Tools, Modular Open Simulations, Open Multi-Scale Data

Additive Manufacturing Technology Roadmap Level 1

	2014	2015	2016	2017	2018

Design
- Bio-Inspired Design & Manufacturing
- Product & Process Design Aides/Apps
- Cost & Energy Driver Analysis/Modeling

Material
- "Non Ad-Hoc" Additive Manufacturing Tech Data Packages
- Material Property Characterization
- Next-Gen Materials

Process
- Multi-Material Delivery & Deposition Systems
- Next-Gen Machines
- Process Temp Gradient Control

Value Chain
- Standards/Schemas/Protocols
- Rapid Inspection Technologies
- Advanced Sensing and Detection Methods
- Repair Technologies
- Intelligent Machine Control Methods
- Digital Thread Integration

AM Genome
- Benchmark Validation Use Cases
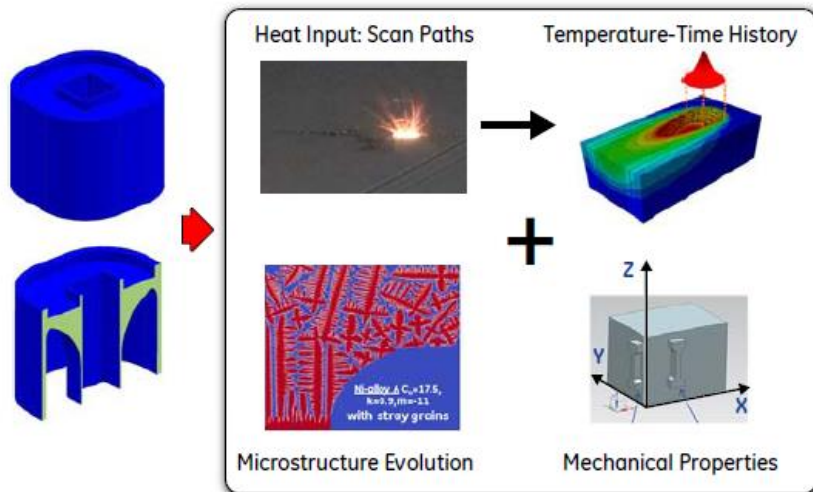- Physics-Based Modeling & Simulation
- Model Assisted Property Prediction

Note: Appendix A has the Level 1 and Level 2 Roadmap in entirety

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AM Roadmapping for the DoD

Project Example: Distortion Prediction

Total project value: Approx. $2.25M

Project team: GE GRC, UTRC, Honeywell, Pan Computing, LLC, University of Louisville, Penn State University, CDI Corporation

Timeline: August 2014 – August 2016

- Reduce the number of process iterations required to build a part using metal powder-bed AM through fast & accurate thermo-mechanical distortion prediction & pre-compensation of part geometry to mitigate distortion

- Accelerate the deployment of AM at large OEM's and SME's through reduced development cost & optimal material usage

- In-depth validation of 2 competing, high-speed, accurate process distortion prediction & compensation methodologies

Our approach to IP

All Consortium
Developed IP is owned
by the inventing
organizations–
We help to conserve,
integrate, and transition.

CONSERVE · INTEGRATE · TRANSITION

You Own Your IP – You will own both pre-existing IP and any you develop through consortium effort.

We Provide Protection – We have a membership agreement in place that is designed to protect your interests by ensuring that all participants play by the same set of rules.

Increase Chances of IP Adoption – We facilitate IP transition through our project-based approach and expansive network that represents multiple industries, markets, and stakeholders.